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JAPAN'S COMMERCIAL AIRCRAFT INDUSTRY:
TRYING TO PULL OUT OF A STALLSummary

Japanese industry today lacks the capabilities to independently design, develop, manufacture and market competitive commercial transports and high-thrust jet engines. But, as the recent controversy over the FSX project demonstrated, a cross section of Congress, the administration and the American public worries that Washington inadvertently is hastening the day when Japanese manufacturers challenge U.S. leadership in the civil aircraft field. Access to F-16 airframe technology, it is maintained, will give Japanese aircraft engineers valuable experience in design, development and systems integration, arguably the industry's biggest handicap. Supporters of the FSX program concede as much, but they assert that the skills and knowledge gained from military aircraft projects are not transferable to the commercial side of the business.

Whether or not experience in military aircraft design and systems integration can be applied to commercial development, Japanese producers never have banked on military technology transfers to improve their capabilities in the civilian area. Their plan for catching up has been straightforward: learning the commercial airframe and engine businesses firsthand through partnerships with foreign builders. This strategy, which has the potentially double benefit of addressing the other constraints hamstringing Japan's commercial aircraft makers, paid off at first. But now the industry is stalled. Boeing Co. has shelved plans to develop an advanced-technology 150-seat plane with Japanese participation, and what was expected to be a cutting-edge

international engine project has not lived up to its advance billing. While Japanese manufacturers cannot afford to abandon the joint venture route, these setbacks increase the importance of any commercial spin-offs that Japan can obtain from the FSX program.

Trying to Move Up

Despite substantial development and manufacturing capabilities, Japanese companies remain bit players in the international commercial aircraft industry, limited to supplying airframe and engine parts to American and European builders or domestic customers. Production of commercial airplanes, subassemblies, parts, related accessories and engines for both the domestic and the export market totaled only \$926 million last year (see Appendix). Even with the strong yen inflating the dollar value of shipments, this output equaled a fraction of comparable 1988 U.S. commercial aircraft sales, conservatively estimated at \$30 billion. To make matters worse, output on the commercial side of the business has expanded by fits and starts, more than doubling in yen terms between 1980 and 1982, then leveling off for four years, jumping again in 1987 and expanding at a scaled-back rate last year.

Corporate sales figures convey the same picture of players still waiting for their big break. Industry leader Mitsubishi Heavy Industries, Ltd. had aerospace sales of \$1.8 billion in FY 1988. But a large part of this 13.4 percent of total revenues came from the company's space operations, and most of the rest represented Japan Defense Agency contracts, the source of roughly 80 percent of the aircraft industry's business year in and year out. Similar caveats apply to the FY 1988 aerospace sales results for Kawasaki Heavy Industries, Ltd. (28.5 percent of the company's revenues or \$1.7 billion) and Ishikawajima-Harima Heavy Industries Co., Ltd. (17.1 percent of the total or \$819 million).

The parts supplier role clearly is not what Japanese industrial policymakers had in mind for the industry 30 years ago. At that time Ministry of International Trade and Industry officials were convinced that with government guidance and financial support Japanese companies could acquire the capability by the 1970s to independently design, develop, manufacture and market internationally competitive commercial aircraft. The technical success of the YS-11, a twin-engine turboprop designed to carry 60 or so passengers on short hauls, initially seemed to vindicate MITI's optimism. But the project turned out to be a commercial flop. Only 182 planes had been built by the time the program ended in 1973, including 76 for overseas customers, and the government, which had covered all of the YS-11's development costs and part of the production costs, got stuck with big losses.

The failure of the YS-11 program, coming on top of the advent of wide-body jets -- planes far beyond the medium-term technical capabilities of Japanese manufacturers, forced the government to rethink its strategy for the

industry. A first for Japanese industrial policy emerged from this review as the indigenous development approach was scrapped, replaced by a less ambitious plan to gain the skills and knowledge to build large commercial transports and high-thrust jet engines through international partnerships. In another switch, policy planners decided that the government would limit future funding of commercial aircraft projects to research and development and then only about half of the costs; manufacturers would have to shoulder the risks of production and marketing alone.

While many foreign analysts in the mid-1970s doubted that the collaborative approach to playing catch-up would be any more successful than the go-it-alone strategy, MITI officials did not share these reservations. To them a world-class Japanese commercial aircraft industry was just a matter of time -- the 1980s, possibly the 1990s. Their confidence partly reflected the rapid advances domestic companies were making in electronics, materials and other product and process technologies relevant to aircraft. The main cause for optimism, however, was the prospect of Japanese participation in the development and production of Boeing Co.'s 767, a twin-engine, widebody, medium-range airliner initially designed to carry 210 to 220 passengers.

The 767 project, launched in the fall of 1977, represented Boeing's first venture with non-American risk-sharing partners -- MHI, KHI, Fuji Heavy Industries, Ltd. and an Italian aerospace consortium. Although MITI was angling for a more substantial role for the Japanese team, the three airframe makers, like their Italian counterparts, have a status somewhere between equity partner and subcontractor. The trio's design and development input was confined to the 767's fuselage sections and wing fairings, and its manufacturing contribution is restricted to these subassemblies plus a few other parts. Moreover, the Japanese companies are not involved in the marketing and sale of the technically advanced 767, which entered commercial service in September 1982.

The financial responsibilities of the Japanese participants were equally limited. Total Japanese development costs came to Y29 billion (\$207.1 million at Y140=\$1.00) over the five years through March 1983. The government put up just over half of these funds -- Y14.7 billion or \$105 million -- in the form of "success-conditional" loans, money that is expected to be repaid when a project becomes profitable. MHI, KHI and FHI covered the remaining development costs and, in addition, invested an estimated Y20 billion (\$142.9 million) or so in production facilities and tooling.

For this risk the Japanese team is guaranteed work on the first 500 767s produced by Boeing. But this guarantee has proved to be a mixed blessing since the project contract is written in dollars. With the run-up in the yen's value, the three companies reportedly are selling fuselage subassemblies to the aerospace giant at a loss. Even so, they have repaid roughly Y5 billion (\$35.7 million) to the government from the proceeds of their 268 deliveries to date.

How much did Japan's aircraft industry learn about the commercial airframe business from its work on the 767? Manufacturers certainly gained experience in the design and development of fuselages for large transports, thanks to considerable input from Boeing, and their manufacturing skills were honed, at least in this area of the airframe. Moreover, with a large group of Japanese engineers stationed in Seattle during the 767's design stage, the industry acquired some familiarity with the use of CAD/CAM (computer-aided design and

manufacturing) in the aircraft field and how to integrate different types of technologies into one system as well as make a plane lightweight and durable. Many industry watchers, however, characterize these gains as incremental increases in knowledge and ability, pointing out that the 767 sections handled by the Japanese side do not involve particularly sophisticated design or production technologies.

Advancement Stalled: Airframes

While the benefits of the 767 program were perhaps more limited than expected, MITI and Japan's airframe manufacturers still were upbeat in the early 1980s about the domestic industry's prospects for a breakthrough since talks were under way with Boeing on a follow-on project -- one involving full Japanese participation in the development and production of a new generation of fuel-efficient, medium-range aircraft in the 150-seat category. But Tokyo's hopes for a quick project start soon were dashed as the discussions, begun in 1980, dragged on year after year. Finally, in March 1986, Boeing and the Japanese trio initialed a memorandum of understanding on a state-of-the-art plane scheduled for delivery in the early 1990s. MHI, KHI and FHI would have the right to participate in every phase of the work from preliminary design through marketing and product support in exchange for funding roughly 25 percent of program costs, then projected at close to \$4 billion, and shouldering the same proportion of the risk.

As things turned out, the MOU signing was the beginning of the end for the all-new 7J7 airliner. After postponing the start of development several times, Boeing put the project on indefinite hold in December 1987. By then the reasons for delay had become depressingly familiar to the Japanese partners. The biggest problem, corporate spokesmen said, was the market's lack of enthusiasm. Key potential customers could not agree on the 7J7's capacity, with airlines indicating an interest in anything from a 140-seat model to a plane carrying 170 or more passengers. In addition, the 7J7's fuel efficiency, expected to be a major selling point when the plane was conceived in the early 1980s, failed to interest carriers because of lower jet fuel prices. Airlines also had reservations about the innovative ultrahigh-bypass (propfan) engines slated to power the 7J7. The cost of the plane's long list of other advanced features worried them as well.

The shelving of the 7J7 left Boeing's Japanese partners in the lurch. By the time the no-go decision was made, the three airframe manufacturers had spent nearly seven years and close to Y8.6 billion (\$61.1 million) of their own or borrowed money plus Y9.7 billion (\$69.6 million) of the government's on preliminary design of an advanced-technology 150-seat plane. This effort, which included independent work as well as the collaboration of up to 120 Japanese engineers with Boeing's 7J7 development team, certainly was not a waste of time or money. Over the near term, however, the industry has no way to apply the knowledge and skills gained since it still lacks the full range of capabilities to develop a competitive airframe.

Having tied the aircraft industry's medium-run fortunes to continued work with Boeing, Japan's industrial policymakers were left stranded as well. MITI officials still hold out hope that the 7J7 project will be revived, but the chances of that happening any time soon are remote. Boeing's resources already are stretched, with output of current aircraft models nearing record levels, production of its latest widebody derivative -- the 747-400 -- behind

schedule and quality issues dogging the company. The only major new effort now under consideration at Boeing is the 767-X, an all-new long-range, 350-seat plane that presumably would incorporate many of the advances pioneered for the 7J7. Japanese participation in the 767-X cannot be dismissed out of hand if Boeing does decide to go ahead with the program, but that solution to the Japanese industry's current stalemate has not been raised, at least publicly.

In the meantime the government continues to support R&D on a 150-seat plane designated the YXX. On top of the ¥18.3 billion (\$130.6 million) invested through March 1988, the three airframe makers put ¥5.2 billion (\$36.9 million) into design work in FY 1988, and they could spend as much as ¥9.6 billion (\$68.5 million) in the current fiscal year. This money, like the funds earmarked for R&D in FY 1986 and FY 1987, came entirely from the International Aircraft Development Fund. Set up in July 1986 to underwrite the costs of government-industry commercial aircraft projects, the quasi-public organization borrows from the Japan Development Bank and makes interest-free loans to manufacturers, using MITI funds to subsidize interest charges. But unlike MITI's previous "success-conditional" loans, the IADF money must be repaid regardless of whether a project moves into the production phase.

Given this catch, the amount of money going into airframe design and development has raised a few American eyebrows. Skeptics wonder if government and industry proponents of an independent development effort, in the minority for the last 15 years or so, now are gaining the upper hand in policymaking circles because of the indefinite suspension of the 7J7 program. MITI decision-makers and corporate executives officially downplay this talk, noting in part that all government-funded commercial aircraft projects must include foreign partners under an April 1986 revision of the 1958 Aircraft Industry Promotion Act. Yet YXX funding levels plus the ups and downs of the V2500 project, the international jet engine consortium involving Japanese companies, are likely to keep this speculation alive.

Advancement Stalled: Engines

Like the 7J7/YXX program, the V2500 project was billed by MITI as the big break needed by Japan's three aircraft engine makers -- KHI, MHI and industry leader Ishikawajima-Harima Heavy Industries. Through an 11-year (FY 1971-FY 1981), ¥19.8 billion (\$141.4 million) project funded entirely by the government, the trio had developed an experimental fuel-efficient, quiet turbofan engine to power 80- to 120-seat planes. To commercialize the FJR 710, however, the companies had to bring in Britain's Rolls-Royce Plc., which had been providing technical advice, at the end of 1979.

By early 1982 the 50-50 partnership was ready to test a 20,000-pound-thrust turbofan engine, a powerplant designed for 130-seat planes, but by then the short-range end of the airliner market seemed to be moving toward 150-seat planes like the proposed 7J7/YXX. Boosting the thrust of the then-designated RJ500 to the required 23,000-pound range would have at least doubled development costs, initially projected at ¥140 billion (\$1 billion). Neither Rolls nor its Japanese partners were willing to increase their financial exposure to that extent. Moreover, MITI, which had covered two-thirds of the Japanese team's ¥17.4 billion (\$124.6 million) in development costs between FY 1980 and FY 1982, reportedly had reservations about the project's greater risks.

With the support of MITI and the three Japanese companies, Rolls went shopping for a third partner, finally selecting United Technologies Corp.'s Pratt & Whitney aircraft division, then the world's top engine builder. That was the easy part. The partners then had to resolve such thorny issues as design specifications, work assignments and financial shares as well as scale some major regulatory hurdles in the United States. In the fall of 1983, however, the International Aero Engines consortium formally was launched to design, develop, manufacture and market the V2500, an advanced-technology turbofan engine for 150-seat planes that promised airlines significant fuel savings and reduced noise.

Rolls and its Japanese partners, drawing on the British firm's shroudless fan design and on the compression work done for the RJ500, were put in charge of the engine's high-pressure compressor and fan. This team has 53 percent of the V2500 work program, split 30 percent for the world's number-three engine maker and 23 percent for the three Japanese companies. Pratt & Whitney, also with a 30 percent work share, was assigned responsibility for the high-pressure turbine and combustor, while its two partners, a West German concern and an Italian firm, were given the low-pressure turbine and gearbox. This team was expected to tap the combustor technology incorporated in the 36,250-pound-thrust PW2037 turbofan developed in the early 1980s for Boeing's medium-range, standard-body 757 jetliner.

The V2500's planned five-year, \$1 billion-plus development cycle got off to a successful start despite the unwieldy nature of the consortium backing the project. But things started to unravel in 1986 when initial engine testing revealed that the Rolls-designed high-pressure compressor could not deliver the desired performance. Until then the V2500 had been on an order roll, winning much of the engine business for Airbus Industrie S.A.'s upcoming 150-seat A320 over the competing CFM56-5A1 derivative developed by General Electric Co. and France's Snecma. The tables turned quickly, however, as the V2500 was hit by a two-year order drought. The redesigns needed to get the powerplant up to its planned configuration hurt sales; so did worries about the consortium's ability to meet its scheduled 1988 type certification date, which already was a year later than the CFM56's. In addition, lower oil prices made airlines less concerned about fuel savings, a major V2500 selling point, and more interested in engine reliability, a big plus for the GE-Snecma team since the CFM56 series has a track record dating back to 1982. To make matters worse, IAE lost one of its few key customers in early 1988 when Lufthansa German Airlines switched its A320 engine order to the CFM56, in part because of doubts about the increased-thrust potential of the basic V2500 engine, rated at 25,000 pounds.

IAE's success in achieving its mid-1988 type certification target was the first step toward restoring the credibility of the consortium, which reportedly was plagued by infighting because of the V2500's technical problems. The group's ability to meet its five-year-old goal of having the first V2500 engine in service by the spring of 1989 (May, as it turned out) also helped. Moreover, the project got a major vote of confidence at the start of 1989 when Braniff Inc. placed a big order. The CFM56-5A1, which entered into service in April 1988, still has a big lead in firm orders -- 817 versus 350 for the V2500 -- as well as in options (442 compared with 158), but the GE-Snecma team and IAE are running neck and neck on deliveries, with both close to shipping out their 100th powerplant for the twin-engine A320.

IAE executives are confident that over the long run the new-technology features of the V2500 and its better fuel efficiency will give the engine a sales advantage over the derivative CFM56. Industry analysts do not necessarily agree with this proposition, but unless the consortium does take the lead, the partners are unlikely to recover their development costs. These costs continue to add up since the companies are studying an increased-thrust (28,000 pounds) version of the V2500 for certification in the 1992-93 time frame as well as trying to reduce the weight and fuel efficiency of the basic engine.

Development costs for IAE's three Japanese partners already are high, particularly measured against what they are thought to have gotten out of the international tie-up. Through March 1989 Japan's total tab for the V2500 was Y60.3 billion (\$430.7 million), including the Y17.4 billion (\$124.6 million) spent on the work with Rolls in the early 1980s. Loans from commercial banks and the International Aircraft Development Fund financed Y23.1 billion (\$164.8 million) of these outlays, and the trio of engine makers could borrow up to Y4.6 billion (\$32.7 million) from IADF during the current fiscal year.

Industry experts guess that this money has bought IHI, KHI and MHI only a marginal increase in capabilities. As IAE junior partners their design and production responsibilities cover a relatively low-technology section of the V2500. Moreover, to satisfy U.S. antitrust concerns about a partnership involving two of the three biggest engine manufacturers in the world, the consortium is structured in such a way that each of the seven participating companies has complete charge of a separate part of the engine, and the only technical data exchanged is what is necessary to interface the sections of the modular engine.

Finding the Cause

While the catch-up process seems to have stalled, Japan's commercial aircraft industry does have strengths. Airframe companies are well-versed in designing and making parts -- not just fuselage subassemblies for the 767 but a variety of components for other Boeing aircraft, particularly the 747 series, as well as for McDonnell Douglas Corp.'s MD-80 family of medium-range commercial transports. Similarly, the experience of engine producers extends beyond developing and manufacturing a section of the V2500 to small shares in two Pratt & Whitney commercial engine programs. Moreover, airframe and engine firms alike continue to invest in their own R&D (including in the engine area work on propfan propulsion) to expand their proprietary know-how. Japan's other high technology industries bring additional strengths to the aircraft field, especially in the areas of avionics and aerospace materials, and these are backstopped by the country's overall manufacturing prowess and quality control systems. Then, too, the commercial side of the business has had the benefit of technological spin-offs from a succession of military coproduction programs with the United States, although the extent of this help is much debated.

The fact remains that these strengths, although considerable, do not add up to the capability to design, develop, manufacture and market internationally competitive commercial transports and high-thrust engines. Analysts disagree about the Japanese industry's major handicap, but the leading candidate is its limited experience in airframe systems design and integration -- the technically demanding science of translating aerodynamic theory into an aircraft that meets targeted performance requirements and, in the final step, fitting numerous subassemblies made up of thousands of parts and components into a workable

structure. Japan's only attempt to develop and build a commercial airliner from the ground up was the YS-11 and, while the plane was a technical success at the time, its technology now is at least two generations old.

The industry's engineering and production experience is more extensive on the military side of the airframe business, but many experts question the relevancy of this background to commercial aircraft. Its initial attempt at independent development was a trainer, which are easier to design and build than fighters. Prime contractor Mitsubishi Heavy Industries began basic design work on the T-2 advanced jet trainer in FY 1967 and delivered 96 of them to the Japan Defense Agency between 1975 and March 1988. Japan's top airframe builder subsequently reworked the T-2 into the F-1 close support fighter. Smaller, slower and less capable than the F-4 developed in the late 1950s by McDonnell Douglas and the F-15 designed in the late 1960s by the same company, the 77 F-1s built by MHI between mid-1977 and March 1987 have several serious design flaws.

The latest indigenous military program, the T-4 intermediate jet trainer, is a big step up from the T-2/F-1 project. Both the airframe and the engine -- IHI's F3-30 turbofan -- were developed entirely in Japan, a first for the industry. The head-up display, on-board oxygen system and ejection seats are the only foreign equipment used in the plane, which features such technologies as digital avionics and the extensive use of composites. The T-4 also represents Japan's first use of CAD/CAM to design and build an aircraft. Moreover, under prime contractor Kawasaki Heavy Industries, which began development work in October 1981, the project came in on schedule and within budget, and the prototypes reportedly met all design specifications during flight testing. The first T-4 out of an order for 200-plus was delivered to JDA in the fall of 1988.

Ironically, some of the industry's best commercial aircraft technology is sitting on an unused airport runway in central Japan. Between 1977 and March 1989 the government's National Aerospace Laboratory spent Y38 billion (\$271.4 million) to come up with a quiet, fuel-efficient STOL (short takeoff and landing) plane. By all accounts, foreign as well as domestic, the engineers succeeded, developing a research aircraft code-named Atsuka with world-class STOL capabilities. Atsuka is a modified KHI C-1 tactical transport with a new wing design powered by four 11,000-pound-thrust IHI/NAL FJR 710/600 turbofan engines. Among the state-of-the-art technologies incorporated in the entirely made-in-Japan plane are "fly-by-wire" controls, which replace mechanical and hydraulic cockpit controls, and a digital flight control system. Most notably, Atsuka needs about half the distance to take off as a 737, Boeing's smallest jet, and roughly 30 percent of the distance to land. This capability is ideal for the huge number of runways around the world that are too short to handle conventional jets. For cost reasons, however, neither the government nor the industry has any near-term plans to commercialize the STOL technology.

This irony highlights a truism: technical shortcomings are just the first of several factors standing in the way of the Japanese aircraft industry becoming a player in the international commercial transport market. Cost is another. The bill for designing, developing, testing and certifying the airframe for an all-new large (120 seats or more) plane starts at \$2 billion and jumps from there depending on how much advanced technology is incorporated, while getting the plane into production can cost another \$1 billion or so. The

price tag for bringing a new high-thrust engine to the market is equally stiff -- roughly \$1.5 billion. And no guarantees come with these enormous outlays. As people in the industry are fond of saying, airframe and engine manufacturers bet the company every time they introduce a new product. Even if a winner does come up, the payback period is long -- at least 10 years for a plane.

The high-risk stakes in the commercial aircraft business have narrowed the competition in large jetliners to Boeing, McDonnell Douglas and Airbus, with a trio -- Pratt & Whitney, GE and Rolls -- also fighting for market share in high-thrust engines. Of the three airframe manufacturers, only Boeing consistently has made money from commercial aircraft in the 1980s, and even its profits were sliced in the early years of the decade as the airline business slumped just as the company was introducing its 767 and 757 and rolling out new versions of its 737 and 747. McDonnell Douglas has not financed an all-new commercial plane in more than 20 years; its MD-80 series of medium-range planes is a spin-off of the DC-9 and the widebody, long-range MD-11 is a DC-10 derivative. For its part, Airbus has been able to stay in business since its founding in 1970 only because the four European governments backing the consortium have been willing to pump billions of dollars -- \$14 billion, according to a 1988 estimate -- into the operation, which now is the world's second-largest maker with a technically advanced product line that soon will match Boeing's lineup across-the-board.

Despite MITI's ambitions for the domestic aircraft industry, the Japanese government is unwilling to go the route of its French, West German, British and Spanish counterparts, at least on the manufacturing side. That means that should Japanese aerospace companies somehow acquire the wealth of technical expertise needed to break into the international commercial aircraft market alone, they would have to cover most of the costs themselves and shoulder all of the risks. This is one gamble manufacturers, whether airframe builders or engine producers, will not take, particularly since they cannot even count on Japanese airlines to buy domestic.

The long list of Japanese industries that have become world-class competitors over the last two decades invariably launched their international marketing efforts from a strong domestic sales base. Airframe or engine makers would not have that edge. Aside from the fact that the Japanese market is too small to absorb the roughly 400 to 600 planes (depending on the model) a manufacturer needs to sell to break even, airlines have a vested interest in maintaining commonality across the different range of planes and engines in their fleet since they can obtain significant savings in maintenance and training. Japan Airlines Co., Ltd. has an almost all-Boeing fleet now powered entirely by Pratt & Whitney engines. The same is basically true for All Nippon Airways Co., Ltd. But in November 1988 ANA, after deciding to add 20 A320s to its fleet, defied government and industry expectations and ordered 50 CFM56-5A1 engines for the planes instead of the V2500. In putting a performance record ahead of nationality, Japan's second-largest carrier delivered an expensive reminder to the domestic aircraft industry of how it might fare in the international marketplace.

FSX to the Rescue?

Despite the Japanese aircraft industry's multiple handicaps in the commercial field, which also include limited experience in international marketing

and product support, most trade and industry watchers zero in on its shortcomings in the airframe systems design and integration area. The proposed 7J7 program and before it the 767 project both led to charges at the time that Boeing was helping a future competitor eliminate its main weakness in exchange for financial support and less risk exposure over the medium term. The estimated \$14.5 billion in military coproduction arrangements with Japan between 1977 and 1988 also provoked heated talk in some government and business circles about technology giveaways. No wonder then that Washington's decision to release the airframe technology for General Dynamics Corp.'s current F-16 to Japan for its next-generation FSX close support fighter triggered a whole new debate about technology sharing (see JEI Report No. 21A, May 26, 1989).

Under the FSX memorandum of understanding initialed by Washington and Tokyo in November 1988 and the April 1989 side letters, General Dynamics will work side by side with project manager Mitsubishi Heavy Industries on the design, development and integration of a modified F-16 -- changes that are being called a half-generation update rather than a radical redesign of the F-16, which already has undergone three major revamps since it was developed in the mid-1970s. Among the planned modifications are a bigger wing and longer fuselage to increase the plane's range and payload specifications; a larger nose to accommodate radar optimized for maritime search; the use of composite materials in what is now the F-16's all-metal fuselage; and the incorporation of Japanese avionics and instrumentation.

MHI and its Japanese subcontractors will have to depend on a considerable amount of in-house technology to design and develop the FSX's airframe and electronics systems since the United States has placed strict limits on the outflow of F-16 technology. MHI engineers will have access to basic information on the aerodynamic characteristics of the plane -- a first for the F-16 coproduction program. They also will be able to tap the design know-how of the General Dynamics engineers working on the FSX team. At the same time, however, Japanese industry will not get any information on source codes (software instructions) that would allow extensive modification of the software for the computers that control the F-16's avionics and instruments. Commercially sensitive hardware technologies also will not be transferred -- a ban that includes the F-16's fly-by-wire and digital flight control systems as well as high-temperature components and very high-speed integrated circuits. Moreover, no engine technology will be made available to Japan. Engines for the six prototype FSXs will be bought off-the-shelf from the two F-16 engine builders, GE and Pratt & Whitney. (Pratt's F100, used to power the F-15 as well as the F-16, already is made under license by IHI for the coproduced F-15J.)

There is no debate over whether the FSX program will give MHI and its Japanese subcontractors broad capabilities in the design, development and integration of current-generation fighter aircraft. Even embattled American proponents of the deal concede as much, although they point out that by the time MHI reaches the FSX integration stage, U.S. defense contractors will be working on the next-generation ATF/ATA fighter. The question instead is whether the skills and the knowledge Japanese industry acquires from the FSX project can be applied to the commercial part of the aircraft business.

Supporters of the FSX codevelopment arrangement state flatly that there are no technical linkages between the two sides of the aircraft industry.

Presumably behind this bald assertion is the fact that the performance requirements of large commercial transports and fighters are worlds apart. Jetliners are optimized for load-carrying capability, affordability and maintenance and operating costs (including fuel). The performance envelope is much wider for fighters -- maneuverability, speed, ability to withstand stress, weight, to name the major ones -- and these requirements involve more delicate trade-offs than for commercial planes. In addition, costs -- initial as well as operating and maintenance -- are secondary.

Critics of the F-16 technology transfer are equally adamant that the experience Japanese industry gains in FSX airframe design, development and integration is generally applicable to commercial aircraft programs. Their only wavering comes on the issue of whether these capabilities are directly transferable. Certainly no one in this camp expects the FSX project to close Japan's current 10-year-plus technology gap in large transports, in part because Japanese aircraft manufacturers are chasing a moving target in trying to catch up with Boeing, McDonnell Douglas and Airbus. At the same time, though, much of the avionics work the Japanese team will be doing on the FSX unquestionably is relevant to commercial aircraft -- fly by wire, digital flight control, inertial navigation. The main exceptions here are systems that are strictly military in nature like the electronic warfare set and the FSX's fire-control computer, although some avionics technology Japanese industry expects to develop, such as the phased-array radar, might not be cost-effective in commercial aircraft. Other areas where commercial spin-offs from the FSX project are likely include composites and hydraulics.

Hedging Bets

MITI and Japan's aircraft industry certainly hope the second school of thought proves right, but they are not waiting idly to find out. Off and on over the last five years industrial policymakers and executives of the industry's trade association have given serious consideration to the development of an advanced-technology commuter plane. Their initial target was an aircraft in the 100-seat range, but this plan was scrapped after projections put development costs at Y300 billion (\$2.1 billion) and up. By the time the short-haul option was taken up again in 1988, government and industry executives had lowered their sights to the 50- to 100-seat range. They finally settled on a 75-seat commuter, and MITI got Y98 million (\$700,000) put in the FY 1989 budget for a two-year feasibility study.

The consultants doing the study are proceeding on the assumption that the code-named YS-X program will be an international joint venture. Some rough calculations done in 1988 indicated that project participants would have to sell more than 600 planes to break even on their estimated Y100 billion (\$714.3 million) investment but that carriers in Japan could be expected to take fewer than 100 of the planes. So far, though, planners can give prospective partners only a general idea of the YS-X's design requirements: affordability, reduced noise and high speed. The noise and speed criteria make the proposed twin-engine plane's powerplant critical to the success of the project, analysts say. In fact, they estimate that the development costs for the engine could exceed those for the advanced-technology airframe. Government and industry reportedly are considering an all-Japanese engine, possibly a derivative of the IHI F3-30 turbofan used to power the T-4 trainer.

Japan's interest in a 75-seat commuter comes at a time when U.S. aircraft industry executives and analysts are saying that the market both here and abroad is moving toward bigger planes because of increasing passenger traffic and congested airports as well as carriers' desire to lower seat-mile costs as traffic expands. Boeing, for example, projects that 90 percent of the aircraft delivered after 1995 -- the time frame MITI has in mind for the YS-X -- will have more than 170 seats. But Japan's proposed strategy for breaking into the commercial aircraft business has several attractions. For one, regional airline passenger traffic in the United States, which undoubtedly would be the main market for the YS-X, has grown 16 percent a year since the airline industry was deregulated in 1978, in part because major American carriers have gone to a hub-and-spoke system. Moreover, by going after the larger commuter plane market, Japan would stay out of the fray between Boeing and Airbus. All of the competitors in the commuter niche are second-tier players in the commercial aircraft business. All of them also are non-American; in fact, no planes in the 20- to 120-seat category are built in the United States.

Nevertheless, the number of aircraft builders targeting the international market for big commuter planes is high relative to projected demand. Among these producers are de Havilland Aircraft of Canada, Ltd., now owned by Boeing, which makes the 50-seat-plus Dash 7 and Dash 8; British Aerospace Plc. and its 64- to 72-seat BAe ATP plane; Holland's Fokker NV, which markets the 50-seat Fokker 50 and is considering a stretched version carrying 62 passengers; a joint venture between Aeritalia S.p.A. and Aerospaziale S.A. that has just added the ATR72, a 64- to 74-seat transport, to the 48-passenger ATR42 and is studying development of an 80- to 100-seat plane with a Spanish company; Saab-Scania AB of Sweden, the producer of the 50-seat Saab 2000; and West Germany's Messerschmitt-Boelkow-Blohm GmbH, which already has extended an informal invitation to Japan to join it and a Chinese company in the development of the MPC75, a twin-engine, 80-seat plane.

The crowded larger commuter market could scotch Japan's YS-X plans, an outcome that would leave aircraft manufacturers no closer to becoming players in the international commercial transport business than they were 30 years ago. Alternatively, the competition could provide a YS-X partner since a number of current market participants are looking for additional resources -- financial, if not necessarily technical. Japanese aircraft industry executives, however, are certain to think long and hard about accepting a junior partnership, particularly with a second-tier player. Either way, then, Japanese manufacturers could remain suppliers of parts -- albeit increasingly higher value-added parts -- to the world commercial aircraft industry for the foreseeable future.

For further information, contact Susan MacKnight.

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The views expressed in this report are those of the author and do not necessarily represent those of the Japan Economic Institute.

JEI Report will not be published September 8, 1989 because of the Labor Day holiday. The next report will be dated September 15, 1989.

APPENDIX

Aircraft Production in Japan, 1980-88

(in thousands of dollars*)

<u>Year</u>	<u>Total</u>	<u>Customer</u>				<u>Total (million yen)</u>
		<u>Defense Agency</u>	<u>U.S. Military</u>	<u>Domestic Market</u>	<u>Export Market</u>	
1980	\$928,870	\$758,737	\$4	\$90,315	\$79,814	Y210,612
1981	1,037,227	790,451	0	84,629	162,147	228,750
1982	1,484,704	1,127,019	0	119,130	238,554	369,810
1983	1,494,106	1,139,657	80	159,151	195,217	354,865
1984	1,828,141	1,502,867	0	139,660	185,614	434,220
1985	2,278,117	1,928,142	0	158,099	191,876	543,422
1986	2,997,009	2,500,214	0	250,469	246,327	505,056
1987	3,736,601	2,990,390	0	394,967	351,244	540,462
1988	4,180,858	3,254,967	0	460,179	465,712	535,777

Aircraft Repair in Japan, 1980-88

(in thousands of dollars*)

<u>Year</u>	<u>Total</u>	<u>Customer</u>				<u>Total (million yen)</u>
		<u>Defense Agency</u>	<u>U.S. Military</u>	<u>Domestic Market</u>	<u>Export Market</u>	
1980	\$235,578	\$186,518	\$7,917	\$39,353	\$1,791	Y53,415
1981	251,582	201,791	9,976	37,612	2,204	55,484
1982	272,776	209,619	8,499	52,915	1,742	67,943
1983	288,737	220,690	14,143	51,072	2,834	68,578
1984	305,368	220,744	15,982	65,700	2,943	72,531
1985	322,084	235,981	13,142	69,116	3,844	76,830
1986	507,507	376,454	19,380	105,252	6,415	85,525
1987	640,846	461,829	30,462	140,501	8,054	92,692
1988	704,128	534,023	16,964	140,515	12,626	90,234

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Production of Aircraft and Aircraft Engines in Japan, 1984-88

(in units)

	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
Aircraft	120	125	92	111	149
Fixed-Wing Planes	47	48	43	53	70
Piston-Engine Planes	0	1	0	0	1
Turbojet Planes	40	39	35	42	59
Turboprop Planes	7	8	8	11	10
Helicopters	32	44	31	49	50
Other Aircraft	41	33	18	9	29
Engines	131	128	102	123	178
Piston Engines	8	0	0	0	0
Turbojet Engines	51	65	46	49	74
Turboprop Engines	20	31	30	43	59
Turboshaft Engines	48	32	26	31	45
Other Engines	4	0	0	0	0

Production of Aircraft and Aircraft Engines in Japan by Customer, 1984

(in units)

		<u>Customer</u>		
	<u>Total</u>	<u>Defense Agency</u>	<u>Domestic Market</u>	<u>Export Market</u>
Aircraft	120	93	5	22
Fixed-Wing Planes	47	32	0	15
Turbojet Planes	40	25	0	15
Turboprop Planes	7	7	0	0
Helicopters	32	22	4	6
Other Aircraft	41	39	1	1
Engines	131	124	7	0

Production of Aircraft and Aircraft Engines in Japan by Customer, 1988

(in units)

		<u>Customer</u>		
	<u>Total</u>	<u>Defense Agency</u>	<u>Domestic Market</u>	<u>Export Market</u>
Aircraft	149	102	7	30
Fixed-Wing Planes	70	40	0	30
Piston-Engine Planes	1	1	0	0
Turbojet Planes	59	29	0	30
Turboprop Planes	10	10	0	0
Helicopters	50	43	7	0
Other Aircraft	29	29	0	0
Engines	178	177	1	0

Aircraft Production in Japan by Product and Customer, 1984

(in thousands of dollars*)

		Customer			Total
	Total	Defense Agency	Domestic Market	Export Market	(million yen)
Aircraft	\$647,411	\$599,015	\$3,406	\$44,990	¥153,773
Fixed-Wing Planes	520,200	506,101	0	14,100	123,558
Turbojet Planes	398,682	384,582	0	14,100	94,695
Turboprop Planes	121,518	121,518	0	0	28,863
Helicopters	119,304	85,104	3,351	30,848	28,337
Other Aircraft	7,907	7,810	55	42	1,878
Fuselage Parts	560,866	400,316	49,192	111,359	133,217
Engines and Parts	379,151	325,008	45,234	8,909	90,056
Engines	231,614	228,890	2,724	0	55,013
Piston Engines	25,059	25,059	0	0	5,952
Turbojet Engines	172,394	172,394	0	0	40,947
Turboprop Engines	16,984	16,984	0	0	4,034
Turboshaft Engines	16,992	14,268	2,724	0	4,036
Other Engines	185	185	0	0	44
Engine Parts	147,537	96,118	42,510	8,909	35,043
Propellers and Rotors	17,897	17,249	0	648	4,251
Accessories	60,648	50,947	4,896	4,804	14,405
Instruments	93,150	61,439	28,882	2,829	22,125
Training Devices	25,328	24,019	1,309	0	6,016
Support Equipment	43,689	24,874	6,740	12,075	10,377
Total Production	1,828,141	1,502,867	139,660	185,614	434,220

Aircraft Production in Japan by Product and Customer, 1988

(in thousands of dollars*)

	<u>Total</u>	<u>Customer</u>			<u>Total (million yen)</u>
		<u>Defense Agency</u>	<u>Domestic Market</u>	<u>Export Market</u>	
Aircraft	\$1,382,630	\$1,327,554	\$17,269	\$37,807	¥177,184
Fixed-Wing Planes	987,312	949,504	0	37,807	126,524
Piston-Engine Planes	1,849	1,849	0	0	237
Turbojet Planes	660,148	622,341	0	37,807	84,598
Turboprop Planes	325,314	325,314	0	0	41,689
Helicopters	384,136	366,867	17,269	0	49,227
Other Aircraft	11,182	11,182	0	0	1,433
Fuselage Parts	1,268,076	735,794	240,882	291,401	162,504
Engines and Parts	794,608	672,282	89,973	32,353	101,829
Engines	429,762	429,598	164	0	55,074
Turbojet Engines	287,452	287,288	164	0	36,837
Turboprop Engines	87,304	87,304	0	0	11,188
Turboshaft Engines	55,006	55,006	0	0	7,049
Engine Parts	364,846	242,684	89,809	32,353	46,755
Propellers and Rotors	32,876	31,276	336	1,264	4,213
Accessories	243,988	218,158	14,920	10,909	31,267
Instruments	257,487	176,184	71,463	9,840	32,997
Training Devices	73,578	72,431	952	195	9,429
Support Equipment	127,616	21,288	24,385	81,943	16,354
Total Production	4,180,858	3,254,967	460,179	465,712	535,777

*The yen data were converted into dollars using the following average annual exchange rates:

1980	¥226.74
1981	220.54
1982	249.08
1983	237.51
1984	237.52
1985	238.54
1986	168.52
1987	144.64
1988	128.15

Source: Ministry of International Trade and Industry, Yearbook of Machinery Statistics

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